

We claim:

1. An autothermal reactor for producing synthesis gas comprising:

a mixing chamber having an orifice to expand a heated oxygen containing stream into said mixing chamber and an inlet located adjacent to said orifice and oriented to introduce a hydrocarbon containing stream into the mixing chamber tangentially to said heated oxygen containing stream such that said hydrocarbon containing stream is entrained in said heated oxygen containing stream to mix oxygen in said heated oxygen containing stream with hydrocarbons contained in said hydrocarbon containing stream at a sufficiently rapid rate so as not to react the oxygen and the hydrocarbons, thereby to produce a reactant stream made up of an unreacted mixture of the heated oxygen containing stream and the hydrocarbon containing stream;

an initial partial oxidation reaction zone having a supported partial oxidation catalyst in communication with said mixing chamber and followed by at least two endothermic reforming reaction zones heated by an exothermic reaction of said partial oxidation reaction zone to react the oxygen and the hydrocarbons of said reactant stream and thereby to form said synthesis gas; and

the at least two endothermic reforming reaction zones containing a precious metal catalyst supported on supports formed of materials that provide a greater surface area for a successive of the at least two endothermic reforming reaction zones than an initial of the at least two endothermic reforming

reaction zones directly following the partial oxidation reaction zone, the initial and the successive of the at least two endothermic reforming reaction zones configured to operate at ever decreasing operational temperatures such that a material making up a support of the successive of the at least two endothermic reforming reaction zones remains stable.

2. The reactor of claim 1, wherein:

    said mixing chamber is defined by an inner surface outwardly diverging from said orifice to form a frustum of a cone; and

    said surface outwardly diverging from said orifice at an angle calculated to inhibit re-circulation within said mixing chamber.

3. The reactor of claim 1 or claim 2, wherein:

    said partial oxidation zone is formed by a monolithic support; and

    said endothermic reforming zones are formed by beds of pellets.

4. The reactor of claim 3, further comprising a ceramic heat shield of honeycomb configuration located between the partial oxidation reaction zone and the mixing chamber to inhibit heat transfer from the partial oxidation reaction zone to the mixing chamber.

5. The reactor of claim 3, wherein said monolith is of honeycomb configuration and said pellets of the initial of the at least two endothermic

reforming reaction zones is formed by alpha-alumina and the successive of the at least two endothermic reforming reaction zones is formed by gamma-alumina, respectively.

6. The reactor of claim 3, wherein:

    said mixing chamber is a primary mixing chamber; and

    a secondary mixing chamber is situated between said partial oxidation reaction zone and said at least two endothermic reforming zones, said secondary mixing chamber having a secondary inlet to receive a recycle stream containing synthesis gas components obtained by separation of hydrogen and carbon monoxide from said synthesis gas.

7. The reactor of claim 3, wherein said mixing chamber, said partial oxidation reaction zone and said at least two endothermic reforming zones are in an inline relationship.

8. The reactor of claim 3, wherein the initial of said endothermic reforming reaction zones has a surface area from between about 0.1 and about 10 m<sup>2</sup>/gm and the successive of the at least two endothermic reforming zones has surface areas from between about 5 and about 300 m<sup>2</sup>/gm.

9. The reactor of claim 3 wherein said precious metal catalyst is Pt, Rh, Ru, Pd, or Ni.

10. The reactor of claim 3 where the monolithic support is formed from a ceramic doped with a partial oxidation catalyst.

11. A method of making a synthesis gas comprising;

mixing a heated oxygen containing stream and a hydrocarbon containing stream to form a reactant stream;

the heated oxygen containing stream and hydrocarbon containing stream being mixed at a sufficiently rapid rate such that oxygen and a hydrocarbon content of said hydrocarbon containing stream remain unreacted in said reactant stream; and

autothermally reacting said oxygen and said hydrocarbon content within said reactant stream in an initial partial oxidation reaction followed by at least two subsequent endothermic reforming reactions to form said synthesis gas;

the at least two endothermic reforming reactions being sustained with heat generated from said partial oxidation reaction and by supported catalyst supported on supports formed of materials that provide a greater surface area for a successive of the supports supporting the catalyst involved in a successive of the at least two endothermic reforming reactions than an initial of the supports supporting the catalyst involved in an initial of the at least two endothermic reforming reactions directly following the partial oxidation reaction; and

operating the initial and the successive of the at least two endothermic reforming reactions at ever decreasing operational temperatures such that a material making up the successive of the supports remains stable.

12. The method of claim 11, wherein said heated oxygen containing stream and said hydrocarbon containing stream are mixed in a mixing chamber by expanding said heated oxygen containing stream into the mixing chamber through an orifice and tangentially introducing said hydrocarbon containing stream into said mixing chamber such that said hydrocarbon containing stream is entrained in said oxygen containing stream.

13. The method of claim 12, wherein said oxygen containing stream after expansion has a supersonic velocity and said hydrocarbon containing stream has a subsonic velocity.

14. The method of claim 11 or claim 12, wherein said partial oxidation reaction occurs at a temperature from between about 800°C and about 1400°C and said initial of said at least two endothermic reforming reactions occurs in a temperature range from between about 1000° C. and about 1200° C and the subsequent of the at least two endothermic reforming reactions occurs in a subsequent temperature range of between about 700° C. and about 1000° C.

15. The method of claim 12, further comprising introducing a recycle stream containing synthesis gas components obtained by separation of hydrogen and carbon monoxide from said synthesis gas into said endothermic reforming reactions.